PIETRO MAZZAROTTO BRAGA FIGUEIREDO

EFFECTS OF PRIVATIZING A LOCAL MONOPOLY: A CASE OF A BRAZILIAN OIL REFINERY

Dissertation submitted to the Applied Economics Graduate Program of the Universidade Federal de Viçosa in partial fulfillment of the requirements for the degree of *Magister Scientiae*.

Adviser: Leonardo Chaves Borges Cardoso

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Adviser

To my parents, Sergio and Cristiana, with all my love.

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“Non est ad astra mollis e terris via”.
(Sêneca)

ABSTRACT

FIGUEIREDO, Pietro Mazzarotto Braga, M.Sc., Universidade Federal de Viçosa, February, 2024. **Effects of privatizing a local monopoly: a case of a Brazilian oil refinery**. Adviser: Leonardo Chaves Borges Cardoso.

This study investigates the consequences of recent reforms in the Brazilian oil refining market, focusing on the divestment of Petrobras, a company previously characterized by its monopolistic status. This research focus on the privatization of Brazil's second-largest refinery, the Refinaria Landulpho Alves (RLAM), utilizing difference-in-differences models. The findings indicate a notable increase in end-user fuel prices in Bahia, the state most directly affected by the privatization. Specifically, the study observes that gasoline, diesel, and ethanol prices experienced increments of 0.22, 0.14, and 0.19 BRL per litter, respectively, exceeding the national average. Additionally, the analysis forecasts significant economic implications, estimating a welfare loss of approximately 1.95 billion BRL for consumers in Bahia within the initial 22 months following privatization. These outcomes highlight the intricate effects of market reform policies, especially in critical sectors like oil refining, and suggest the need for further investigation into their wider economic impacts.

Keywords: Privatization, refining market, welfare, difference-in-differences, fuel prices.

RESUMO

FIGUEIREDO, Pietro Mazzarotto Braga, M.Sc., Universidade Federal de Viçosa, fevereiro de 2024. **Título da dissertação ou tese**. **Effects of privatizing a local monopoly: a case of a Brazilian oil refinery**. Orientador: Leonardo Chaves Borges Cardoso.

Este estudo analisa as repercussões das recentes reformas no mercado de refino de petróleo brasileiro, enfocando especialmente no processo de desinvestimento da Petrobras, historicamente conhecida por seu perfil monopolista. A pesquisa foca na privatização da Refinaria Landulpho Alves (RLAM), a segunda maior do Brasil, empregando metodologia de diferença em diferenças. Os resultados encontrados apontam para um aumento significativo nos preços de combustíveis ao consumidor final no estado da Bahia, o mais impactado pela privatização. Registra-se uma elevação nos preços da gasolina, do diesel e do etanol de R$ 0,22, R$ 0,14 e R$ 0,19 por litro, respectivamente, valores esses que superam a média nacional. Além disso, o estudo projeta importantes consequências econômicas, estimando uma perda de bem-estar de aproximadamente R$ 1,95 bilhão para os consumidores baianos nos primeiros 22 meses após a privatização. Estes resultados destacam a complexidade dos efeitos de políticas de visam reformar uma estrutura de mercado, particularmente em setores essenciais como o de refino de petróleo, e reforçam a necessidade de estudos mais aprofundados sobre seus impactos tanto econômicos como sociais de maneira mais ampla.

Palavras-chave: Privatização, mercado de refino, bem-estar, diferença-em-diferenças, preços de combustíveis.

LIST OF ILLUSTRATIONS

LIST OF TABLES

SUMMARY

1. INTRODUCTION

In recent decades, energy consumption has experienced a significant increase, leading to an indissoluble interconnection between energy use and economic activity. This dependency has escalated in parallel with the complexities of industrial development and growing societal demands (COLE, 2006; SHAFIEE; TOPAL, 2008). Fossil fuels continue to account for approximately 80% of global energy consumption, underscoring their persisting dominance (HUSSAIN; KHAN; ZHOU, 2020).

According to Costa and Prastes (2005), oil emerged as the predominant energy source in the 20th century, largely due to the expansion of the automotive industry. It has since played a pivotal role in the development and modernization of economies. Presently, oil remains the foremost source of non-renewable energy, intricately woven into the fabric of production processes and, by extension, the daily lives of a significant portion of the global population, either directly or indirectly.

The petroleum supply chain is bifurcated into two primary segments: upstream and downstream (KANG; PEREZ DE GRACIA; RATTI, 2017). The former involves oil extraction, while the latter encompasses refining, logistics, and the distribution of petroleum products. In Brazil, this market adopts a unique configuration, particularly emphasizing the role of distributors responsible for blending anhydrous ethanol[1] with gasoline for final consumers.

It is crucial to highlight that refining is a central pillar in the oil supply chain, playing a critical role in the downstream segment. This industry transforms crude oil through various physical and chemical processes, collectively termed as oil cracking[2]. This procedure yields products such as diesel, gasoline, petroleum naphtha, and jet fuel. According to the International Energy Agency's (IEA) annual report, comparing the periods 2009-2019[3], the demand for gasoline rose by 9.4 million barrels per day, and diesel demand increased to 15.8 million barrels per day.

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[1] For more information, see Law No. 8,723 of 28 October 1993, which sets the mandatory percentage of anhydrous alcohol added to gasoline at 22%.

[2] For further information read Corma et al. (2018).

[3] Although there is data for 2020 and 2021, the choice was to use 2019 given the impact on demand due to the Covid-19 pandemic.

The construction of an oil production chain has been a strategic approach adopted by developed countries to centralize the production of inputs domestically, particularly during the post-war era (BIRD, 2020). In Brazil, this phenomenon starts in 1950s with the establishment of Petrobras. Its creation was aimed at promoting energy self-sufficiency for the country, which until then had been in the process of development (SMITH, 1972).

The expansion of state responsibility in providing services such as electricity and gas transmission accelerated in developed countries following the Great Depression of 1929 and World War II. This model was later adopted by developing countries, albeit belatedly (BIRD, 2020).

By the late 1970s, several economies began reassessing the role of the state in providing goods and services, triggered by slowing economic growth and escalating inflation in developed nations. This reevaluation, particularly in the United States and the United Kingdom, was epitomized by the elections of Reagan and Thatcher in the early 1980s, signalling a shift towards redefining the state's role in the economy (BIRD, 2020; VICKERS; WRIGHT, 1988).

Megginson, Nash and Van Randenborgh (1994) analysed the operational and financial performance of over 60 companies from 18 countries that underwent privatization between the 1960s and the early 1990s. Their findings revealed notable enhancements in performance metrics, including increases in sales, profitability, capital expenditure, operational efficiency, and labour requirements.

Privatization can be a useful instrument for promoting economic growth and development, contingent upon its careful execution and consideration of each company's specificities. When properly implemented, it can result in increased efficiency and profitability. However, the benefits may not manifest immediately or uniformly across different sectors and regions (MCKENZIE et al., 2003; MEGGINSON; NETTER, 2001).

In Brazil, the momentum for privatization intensified, particularly under President Fernando Henrique Cardoso's administration, beginning in 1995. As Pinheiro (1999) notes, a rapid and significant acceleration of privatization was anticipated, moving beyond the dichotomous stance of the Itamar Franco government. Nevertheless, uncertainties lingered regarding the constitutional reforms enacted that year, especially those aimed at dismantling public monopolies in oil, gas, and telecommunications.

One sector witnessing an escalated privatization process is the electricity sector. Muller and Rego (2021) conducted a comprehensive study comparing privatized and state-owned companies in Brazil. Their findings indicated that privatized entities outperformed their state-owned counterparts in financial aspects, such as reducing operating costs and making continual investments to enhance transmission efficiency. Consequently, the authors argue that consumers of privatized companies benefit from improved service provision.

Thus, privatization, as a strategy to enhance efficiency in the sector, is profoundly transforming the oil production chain in Brazil. The process is gaining pace, especially at Petrobras, which holds a significant position in the refining sector. However, approaching privatization requires caution, considering the unique characteristics of each sector and potential socio-economic impacts.

This cautious approach is particularly pertinent when contextualized within the global landscape of privatization, as outlined by Galiani and Sturzenegger (2008). Their posit reveals that privatization has become a widespread phenomenon over the last two decades, influencing a diverse array of nations with different geographical, ideological, and economic backgrounds. In Brazil, this global trend is reflected in the intensified debate over Petrobras' dominance in the oil sector. As of 2020, Petrobras held a commanding 98.6% of the total refining capacity (CONSELHO ADMINSTRATIVO DE DEFESA ECONÔMICA, 2022), placing it at the centre of the national discussion on the broader implications and outcomes of privatization in such a critical industry.

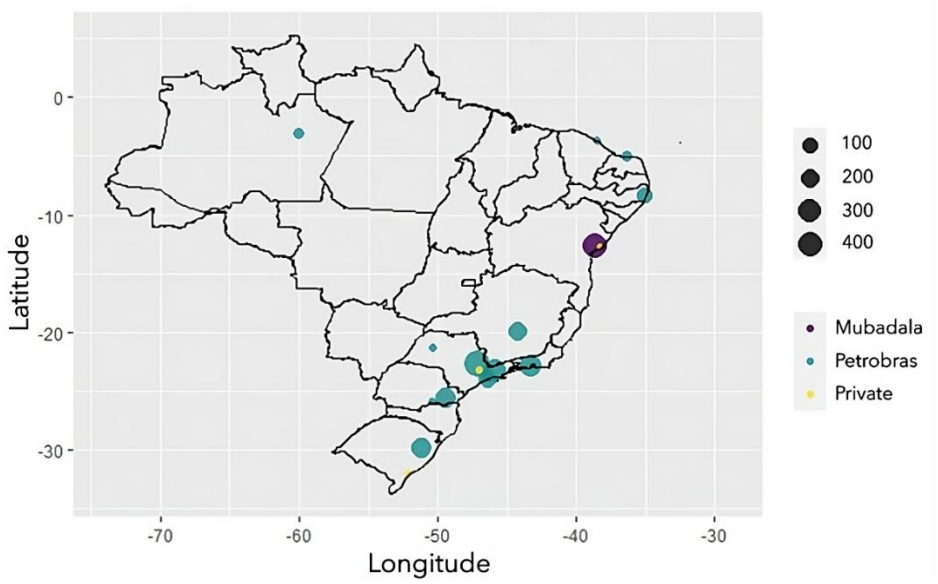
In response to this concentration, a collaborative effort between the Administrative Council for Economic Defense (CADE – Conselho Administrativo de Defesa Econômica) and Petrobras was initiated to diminish the company's dominance in refining and foster economic growth through competitive market dynamics. This initiative led to CADE's approval in July 2021 of the Landulpho Alves Refinery (RLAM) acquisition by Mabudala Capital, a group based in the United Arab Emirates.

Understanding the potential for demand substitution is vital for comprehending the competitive dynamics in the fuel sector. In Brazil, alternative fuels such as ethanol are significant in substituting gasoline, creating a unique market landscape for new entrants (ANP, 2021). However, transitioning towards a diversified and competitive refining market remains a formidable challenge.

Efforts by the government to liberalize the sector are hampered by substantial barriers, including the hefty investments required for the expansion, modernization, or construction of new refineries, and the necessity of duplicating the already extensive distribution infrastructure. Consequently, while establishing a competitive market is complex, it is crucial for enhancing competition and consumer welfare.

Figure 1 illustrates the dispersion of refineries across Brazil. Petrobras, aside from dominating petrochemical production, also leads in refinery ownership. Of the 16 refineries in the country, only six are owned by private entities[4]. The geographical distribution of these refineries often results in the formation of local monopolies, particularly in the North and Northeast regions. Except for Bahia, most states in these regions lack a refinery; only Amazonas, Ceará, Pernambuco, and Rio Grande do Norte host one each.

Figure 1 - Brazilian refining capacity/barrel per day (thousand) in 2021



Source: Elaborated by the author using National Agency of Petroleum, Natural Gas and Biofuels (ANP - Agência Nacional do Petróleo, Gás Natural e Biocombustíveis) data. Notes: The sizes of the circles indicate the refining capacity (in thousands) per day of each refinery. The purple colour corresponds to the Mataripe refinery (formerly RLAM), which was acquired in 2021 by the Emirati group Mabudala Capital and which will be the subject of this study. The refineries under private management are shown in yellow. In green are the refineries belonging to Petrobras.

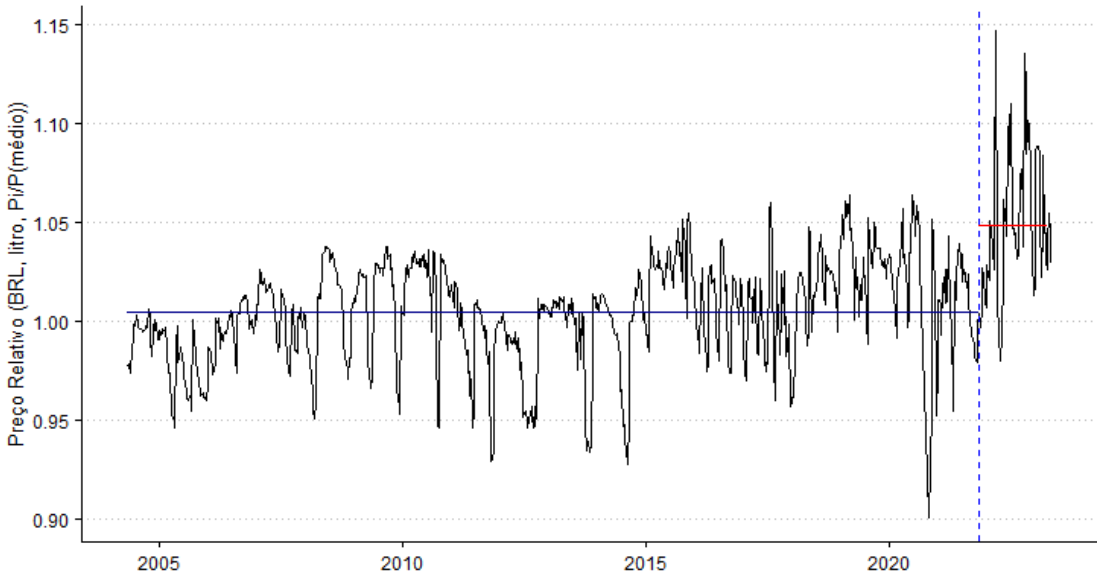
[4] Dax Oil (BA), Manguinhos (RJ), Riograndense (RS), Univen (SP), Refinaria de Mataripe (formerly RLAM) (BA) and Refinaria Isaac Sabbá (AM).

Despite Bahia housing a second refinery, Dax Oil, its production capacity is a mere 0.5% of RLAM's, indicating a significantly weak market power and suggesting a local monopoly by RLAM in oil refining.

According to the National Agency of Petroleum, Natural Gas and Biofuels' Statistical Yearbook (2021), in 2020, the Paulínia Refinery (REPLAN) accounted for 17.4% of the nation's total production, with RLAM responsible for 14%, making it the second largest in volume produced. RLAM's impact is particularly pronounced in the Northeast, despite the presence of other refineries in the area.

Observing the trend of petrol sales prices in the state of Bahia compared to the national average, as depicted in Figure 2, reveals a divergence post-privatization. Before the privatization, the petrol price in Bahia closely mirrored the national average. However, following the privatization, the relative prices increased to approximately 1.05, meaning they were about 5% higher than the national average. It is imperative, therefore, to scrutinize the ramifications of privatization, considering that fluctuations in fuel resale value exert both direct and indirect societal impacts.

Figure 2 - Relative resale price of regular gasoline in Bahia



Source: Elaborated by the author using ANP data. Notes: The relative price of Bahia is calculated by dividing the local price by the national average. The solid blue line indicates the average relative prices before the privatization of RLAM. The red line indicates the average after privatization. The dashed vertical line marks the moment of privatization.

In this context, the findings in Decision Order Number 5/2022/GAB3/CADE (CONSELHO ADMINISTRATIVO DE DEFESA ECONÔMICA, 2022), concerning the privatized RLAM now under MC Brazil Downstream Participações S.A. (ACELEN), becomes particularly pertinent. It revealed potential pricing irregularities in Bahia, with ACELEN's gasoline and S10 diesel prices notably higher than expected, based on logistical considerations. This post-privatization pricing trend not only reflects the intricate challenges of transitioning to private control but also underscores the importance of continuous monitoring and evaluation of market practices in privatized sectors.

The trend towards privatizing local monopolies is intricately linked to factors such as fiscal instability, the drive for cost reduction, and the ideological inclinations of policymakers. This interplay necessitates a reassessment of the State's role in such sectors (BEL; FAGEDA, 2017). In this context, Bel and Fageda (2008) conducted an insightful analysis of the privatization of local water treatment, electricity, and solid waste companies in Spain, discovering a tendency for conservative parties to privatize more frequently.

However, there remains a notable gap in understanding the privatization of local monopolies in the petrochemical sector, with no known equivalent to the RLAM process. Despite RLAM's significant role in the national petrochemical scene, the academic literature is yet to comprehensively address its impacts.

The privatization of the RLAM heralded a wave of significant changes, especially concerning the pricing of gasoline and diesel in the influenced regions. This study hypothesizes that the refinery's shift to private control resulted in increased fuel prices, potentially due to changes in pricing strategies by the new management, alterations in operational efficiency, and a reconfiguration of the market balance, impacting competition and product availability.

The primary objective of this research is to investigate the privatization of the Mataripe Refinery (formerly RLAM) and its effects on the selling prices of gasoline, diesel and ethanol at the gas stations it supplies. This involves identifying any correlation between management changes and fuel price fluctuations. Moreover, the study aims to determine the precise impact on the resale prices of gasoline and diesel from distributors associated with the Mataripe Refinery. Another key aspect is assessing the privatization's influence on social welfare in the refinery's operational

area, to ascertain whether the transition to private management entailed losses or gains for the local community.

Thus, this research seeks to broaden the discourse on the implications of privatization in the refining market, with a particular focus on analysing the short-term effects on the resale prices of gasoline and diesel at the supplied gas stations. This study's relevance is underscored by its pursuit of empirical evidence on the proposed relationship, which could foster future research on the regulatory role of refineries and their productive efficiencies relative to societal returns. This is crucial given the existing gap in specific literature on the subject.

This work is organized into five sections, following this introduction. The second section offers a literature review on local monopolies and privatization. The third section outlines the methodology and data used. The fourth section discusses the results obtained from the estimates, and the fifth and final section presents concluding remarks.

2. LITERATURE REVIEW

The tangled interplay of economic forces significantly shapes consumption interactions and patterns, thus impacting economic welfare (BAUMOL, 1964; MORGENSTERN, 1948; YARROW, 1986). Within these structures, imperfections such as market failures can arise, notably in the form of monopolies. Characterized by the singular presence of one firm, monopolies distinctively set prices, as opposed to the market-determined pricing in perfect competition scenarios (VISCUSI; HARRINGTON; SAPPINGTON, 2018).

Monopolies often emerge due to high barriers to entry, such as the substantial costs involved in establishing a production plant. In Brazil's oil sector, Petrobras serves as a prime example of a legal monopoly. In sectors of societal significance like oil exploration and refining, the state's role as operator and manager becomes essential. This reflects the concept of natural monopolies, especially pertinent in economically and strategically important sectors, including water and sewage treatment, and electricity transmission. (BRADBURD, 1995; VISCUSI; HARRINGTON; SAPPINGTON, 2018). The nature of production costs also plays a critical role in monopolistic market power. High fixed costs and economies of scale, coupled with decreasing marginal costs, render competition inefficient in such contexts (BAUMOL, 1964).

Differentiating between general monopolies and local monopolies is essential for comprehending market dynamics in varying contexts. As Anton and Gertler (2004) note, monopolies typically operate on a large scale, encompassing national or global markets, without geographical constraints. In contrast, local monopolies, as discussed by Gonzalez and Mehay (1987), possess exclusive control over goods or services within specific geographical confines, influenced by local demographics and economic factors.

The privatization of local monopolies, particularly prominent in the 1980s and 1990s, forms the crux of this study. From the public choice theory perspective, Niskanen (1971) views public administrators as aiming to maximize public budgets and power, often resulting in excessive, inefficient government services that may not align with citizens' desires.

Privatization is proposed to enhance efficiency and public welfare. Driving factors for local privatization are twofold: economic and political. Governments may resort to privatization due to fiscal constraints, while political leaders might be motivated by ideological convictions and pressures (BROWN; POTOSKI, 2003). One argument favouring privatization is the potential for cost reduction, often more challenging under public management. Public sectors typically provide services universally, irrespective of payment capacity, whereas private entities can selectively serve paying clients. Furthermore, public bodies often exhibit greater bureaucratic and hierarchical structures than private organizations, potentially leading to less efficient decision-making (SHESHINSKI; LÓPEZ-CALVA, 2003).

Considering natural monopolies, barriers to entry are paramount in understanding competitive dynamics (BAUMOL, 1977; CAVES; PORTER, 1977). Barriers range from patents to the high costs of establishing production facilities.

Concurrently, public entities must vigilantly mitigate potential anti-competitive behaviours emerging from such market structures. As Bain (1951) highlights, a direct correlation exists between market power and profitability, a notion especially pertinent in monopolistic contexts.

Economic regulation is crucial during the transition from public to private administration, aligning the interests of privatized monopolies with societal needs (BROWN; POTOSKI, 2003; LAFFONT; TIROLE, 1993). In Brazil, regulatory agencies play a vital role in enforcing market rules, ensuring competitive and ethical behaviour through economic regulation policies.

Specifically, in the Brazilian oil industry, the National Petroleum, Natural Gas and Biofuels Agency (ANP) regulates and oversees oil, natural gas, and biofuels industries activities. It aims to ensure nationwide fuel supply while protecting consumer interests regarding product price and quality (FRANKLIN; ALVES; QUEIROZ, 2013).

3. METHODOLOGY

3.1 Empirical Strategy

The empirical strategy employed in this study involves the difference-in-differences (DD) method, a quasi-experimental identification strategy that follows the principles of randomized experiments (CUNNINGHAM, 2021). Given that consumers of automotive fossil fuels were not involved in the decision-making process of the RLAM privatization, this event can be considered an exogenous shock, suitable for a quasi-experimental framework.

For effective application, the DD method necessitates the formation of two distinct groups: a treated group, which experiences the policy impact—in this case, the privatization of the refinery—and a control group, which remains unaffected by it.

A key hypothesis underpinning the difference-in-differences approach is the assumption of parallel trends. Essentially, this means that prior to the intervention (privatization), both the treated and control groups should exhibit similar trends or trajectories in the relevant outcome variable (ABADIE, 2005).

The mathematical expression of the proposed methodology is defined by the equation:

$$P_{it}^{j} = \alpha + \varphi T_{it} + \beta X_{it}' + \gamma_i + \delta_t + \varepsilon_{it} \quad (1)$$

Where P_{it}^{j} represents the sales price at gas station i for product j in time period t, α represents the intercept coefficient. The variable T_{it} is defined according to the following criteria:

$$T_{it} \begin{cases} 1, \text{if it suffered intervention after the introduction of the policy} \\ 0, \text{otherwise} \end{cases}$$

A matrix, X_{it}' is added, with observable characteristics, also known as the covariate matrix, in order to isolate the effect of the policy. In turn, $\gamma_i$represents a binary variable relating to the geographical location of the gas station, given a value of 1 if it is located in the state of Bahia, 0 otherwise. δ_t represents a dummy variable relating to the period, with a value of 1 for the period after the privatization of the Landulpho Alves Refinery. The idiosyncratic error is represented by ε_{it}.

Data used in this subsection comes from the Sistema de Levantamento de Preços of the Agência Nacional do Petróleo, Gás Natural e Biocombustíveis (ANP). The survey is released weekly, and each observation has the gas station identification, full address (state, municipality, street, number, and zip code), gasoline, diesel, and ethanol end-user prices and gas station brand.

3.1.1 Robustness

To ensure the validity and reliability of the results, it is essential to perform robustness checks, particularly when employing difference-in-differences models. These checks ensure that the estimated coefficients and standard errors remain consistent, regardless of the assumptions or specifications of the model. This study proposes several specifications for robustness tests, as outlined in Table 1.

Table 1 – Robustness test specifications

Specification	Control Groups	Purpose of Specification
I	Only regions outside Northeast	Baseline model
II	Only regions in Northeast excluding BA	Test for regional effect exclusion
III	Only regions outside Northeast and North	Test for non-adjacent regional contrasts
IV	Only regions outside Northeast and the borders of BA	Test for non-bordering states contrasts

Source: Elaborated by author.

The robustness tests designed for this study are meticulously structured to dissect the nuanced impacts of the RLAM refinery's privatization across various geographical spectrums.

Specification II specifically targets the Northeastern regions, excluding Bahia. This approach is critical for evaluating the privatization's impact devoid of RLAM's

direct influence. The objective is to ascertain whether the observed effects of privatization are uniformly felt across the Northeast or are disproportionately amplified by proximity to Bahia. By deliberately excluding Bahia, this specification aims to distinguish if the observed effects are genuinely regional or are significantly influenced by RLAM's immediate vicinity.

Specification III delves into the impact on regions that are neither adjacent to Bahia nor part of the Northeast and North. This approach is crucial in determining the privatization's effects from those regions that are likely to experience direct or immediate repercussions from RLAM. The aim here is to determine whether variations in fuel prices can be attributed to the privatization over a wider geographic area, indicating a more systematic influence of the policy rather than localized disparities due to proximity.

Finally, Specification IV adopts an even more stringent approach by excluding not just Bahia but also its bordering states. This effectively removes any regions within a certain radius of RLAM, meticulously screening out any potential effects influenced by geographical closeness to the refinery. The outcomes of this specification are crucial, as they are intended to verify whether observed changes in fuel pricing are a direct consequence of the privatization policy and not merely an artifact of spatial proximity to the RLAM refinery.

3.2 Measuring Fuel Demand in Bahia

Estimating the demand for fuel in the municipalities of Bahia is a crucial step in measuring the economic welfare impacts of fuel price changes, particularly following the privatization of a major refinery. The proposed estimation equation is tailored to capture the nuances of fuel demand:

$$D_{it}^{j} = \alpha P_{it}^{j} + \beta P_{it}^{a} + \gamma I_{it} + \lambda t + \mu i + \varepsilon_{it} \quad (3)$$

Here, D_{it}^{j} represents the logarithm of the quantity of fuel j sold in liters in municipality i during period t. P_{it}^{j} denotes the logarithm of the price of fuel, while P_{it}^{a} represents the price of the substitute fuel (for gasoline, ethanol is considered and vice versa; for diesel, there is no substitute) and I_{it} indicates the municipal income at

time t. λt and μi are dummies for fixed effects of time and municipality, respectively. ε_{it} represents the idiosyncratic error.

However, the noted issue of simultaneity between price and demanded quantity is a critical one, as it can lead to biased estimates if not properly addressed. The Two-Stage Least Squares (2SLS) estimation methodology is an appropriate solution to this issue. By instrumenting the potentially endogenous price variable with factors external to the municipality's demand, such as the international price of the input and the distance to the nearest refinery or plant, the approach aims to isolate the exogenous variations in price that influence demand. The reduced form is presented as:

$$P_{it}^{j} = \gamma \left(P_t^b \times \frac{1}{D_i} \right) + \theta X_{it}' + \epsilon_{it} \tag{4}$$

Here, $\left(P_t^b \times 1/D_i\right)$ represents the international price of the input (Brent type oil for gasoline demand and sugar for ethanol demand) and the inverse distance between the city and the nearest oil refinery for gasoline demand or the nearest ethanol plant for ethanol demand. This approach aims to capture the combined effects of international prices and distance, as the logistics affect the price composition, just like the value in the foreign market, resulting in a supply-side shock. X_{it}' represents the other exogenous variables previously presented in Equation 3.

The geopolitical and economic influences on the energy sector, as highlighted by Santana et al. (2023), demonstrate the exogeneity of international crude oil prices to local fuel demand. Závadská, Morales and Coughlan (2020) emphasized the significant influence of global crises on Brent oil prices, suggesting that external factors play a crucial role. Considine, Galkin and Aldayel (2021) further stated that the complexity of the global oil market suggests minimal impact from a single refinery's privatization on the global supply of Brent oil.

Concerning the economic impact of ethanol production, Mizik (2020) discussed how global commodity trade, particularly in corn and sugar cane, impacts ethanol production. Quintino, Burnquist and Ferreira (2021) pointed out that ethanol prices in Brazil are influenced more by international sugar prices than by carbon market dynamics. Sajid, da Silva and Danial (2021) emphasized the role of

government policies in biofuel industries, indicating the importance of external factors like international commodity prices and policy shifts.

It can be stated that consumers have no control over the determination of international prices or the location of a particular plant or refinery. Therefore, the incorporated instrumental variable meets the two assumptions of: (i) instrument strength, as it shows a strong correlation with the endogenous variable of the structural model, and (ii) the exclusion hypothesis is met, as it is expected that the variable's correlation with the error term of the structural equation is null.

In justifying this demand estimation approach, it is crucial to emphasize the need for accurate, unbiased estimates when analysing welfare effects. Biased estimates could lead to incorrect conclusions about the impact of price changes on consumer welfare, potentially misleading policy recommendations. The 2SLS method, with its carefully chosen instruments, helps ensure that the estimated effects of price changes on fuel demand.

Moreover, given the context of a privatized oil refinery, capturing the dynamics of fuel prices becomes even more critical. Privatization might alter pricing strategies and market structures, making the understanding of these price effects on demand essential for a comprehensive welfare analysis.

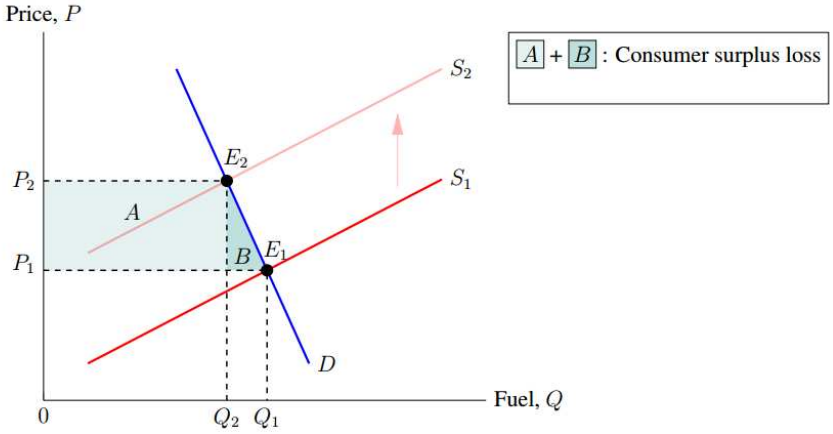
3.3 Welfare analysis

The concept of welfare in economics closely relates to price and income changes among consumers, particularly through the lens of consumer surplus. This surplus, defined as the difference between what consumers are willing and able to pay for a good or service versus what they actually pay, acts as a barometer for economic welfare (DARGAY; GOODWIN, 1995; HAUSMAN; NEWEY, 1995). An increase in consumer surplus, often due to decreased prices or increased incomes, indicates improved economic welfare, while a decrease suggests the opposite.

In the context of the privatization of an oil refinery, such as the case with RLAM, this dynamic plays a crucial role. Privatization can lead to a shift in pricing strategies, often resulting in higher fuel prices due to the monopolistic tendencies that can emerge in the absence of competition. This increase in prices typically leads to a reduction in consumer surplus, particularly impacting those who rely heavily on fuel for their daily activities. The decreased consumer surplus reflects a decline in

economic welfare, highlighting the potential adverse effects of privatization on the general public, especially in sectors as vital as oil and energy.

Figure 3 – Consumer surplus illustration



Source: Elaborated by author based on (BANDEKAR, 2021). The S denotes the supply curve, while D represents the demand curve. The subscripts 1 and 2 indicate the pre and post-privatization scenarios, respectively. The E represents the equilibrium points. The vertical axis represents prices, and the horizontal axis represents quantities.

Furthermore, the disparate impact of these price changes across different income groups is a critical factor in welfare analysis. Increases in essential commodities like fuel can disproportionately affect lower-income groups, who spend a larger portion of their income on these necessities (MATTIOLI; WADUD; LUCAS, 2018). This can lead to a significant reduction in their economic welfare, underscoring the need for careful consideration of socio-economic disparities in analysing the ramifications of privatization in critical sectors like oil refining. The variation in consumer surplus might be measured as:

$$\Delta CS^j = \left(\Delta P^j \times Q_2^j\right) + \left(\frac{\Delta P^j \times \Delta Q^j}{2}\right) \quad (5)$$

Where ΔP^j represents the price variation caused by the privatization of refinery good j. Q_2^j is the quantity demanded after the privatization, and similarly ΔQ^j represents the variation in the quantity demanded, the variation in consumer surplus can also be represented as: $A + B$ areas, as illustrated in Figure 3.

4. RESULTS AND DISCUSSIONS

This analysis primarily focuses on the impact of privatization on fuel prices, drawing upon our baseline results. The data reveals a noticeable increase in the price per litter of gasoline (0.21 BRL), diesel (0.14 BRL) and ethanol (0.19 BRL). A pivotal aspect to consider is ethanol's role as both a gasoline substitute and a component within the gasoline blend sold in Brazil.

Table 2 – Baseline Results: Evaluating the Impact of Privatization on Fuel Prices

	Gasoline	**Diesel**	**Ethanol**
Treated	0.218***	0.141***	0.193***
	(0.021)	(0.022)	(0.030)
Obs.	736,491	980,975	643,438
R^2	0.951	0.969	0.943
Fixed Effect: City	✓	✓	✓
Fixed Effect: Time	✓	✓	✓
Fixed Effect: Brands	✓	✓	✓
Fixed Effect: Capital	✓	✓	✓

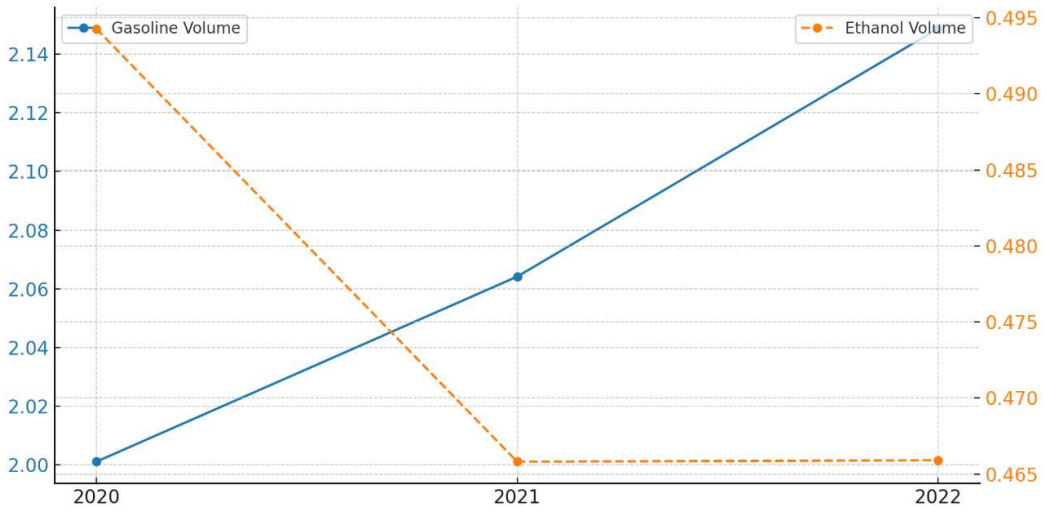
Source: Elaborated by author. Notes: Robust standard errors are in parentheses, adjusted for clustering by city. The symbols *, **, and *** denote rejections of the null hypothesis at significance levels of 10%, 5%, and 1%, respectively. The triple asterisks next to the coefficients indicate a rejection of the null hypothesis at the 1% significance level, suggesting a high level of confidence in the results. In this analysis, fuel prices are examined in their level form; hence, the variable 'Treated' represents the marginal effect of privatization on these prices. City fixed effects are included in the model to account for city-specific variations that could influence fuel prices. Capital fixed effects were excluded from our analysis as they are fully captured by the city fixed effects, ensuring that any observed changes in fuel prices are more directly attributable to the impact of privatization.

Despite this, as evidenced in Figure 4, ethanol's demand not increasing in parallel with gasoline after the privatizing, its pricing is substantially affected by the fluctuations in gasoline prices. This complex dynamic, highlighted in the study by Bentivoglio, Finco and Bacchi (2016), underscores the intricate interdependencies among biofuel, fuel, and food prices, particularly within the Brazilian ethanol market, revealing how shifts in one sector can have far-reaching implications across related markets.

The analysis delves into multiple dimensions, examining the robustness of the results against different geographical. Through this multifaceted approach, the

study aims to fortify the understanding of the privatization's impact on fuel prices. This ensures that the interpretations are not merely artifacts of specific model choices or external influences but are indeed reflective of the underlying market realities.

Figure 4 – Sales Volumes of Gasoline and Ethanol (in millions m³) in Bahia



Source: Elaborated by author using ANP data. Notes: This figure illustrates the sales volumes of gasoline and ethanol over the period from 2020 to 2022, measured in millions of cubic meters (million m³). The blue line represents the volume of gasoline, showing a steady increase over the three years. The orange dashed line represents the volume of ethanol, which exhibits a decline from 2020 to 2021, followed by a plateau from 2021 to 2022.

Focusing on the Northeast region, the study uncovers a noticeable increase in fuel prices following the privatization process. It reports coefficients of approximately 0.12 BRL for both gasoline and diesel, and 0.07 BRL for ethanol. When these figures are compared with those from other states in the Northeast, serving as a control group, it becomes evident that Bahia has experienced a more pronounced escalation in fuel prices. This significant contrast highlights the distinct impact of privatization on fuel prices specifically in Bahia, setting it apart from the general trend observed in the broader Northeastern region. The statistical significance of these findings across various fuel types further solidifies the conclusion that privatization has had a noticeable and specific effect on fuel prices in Bahia.

Table 3 – Robustness Analysis: Evaluating the Impact of Privatization on Fuel Prices over Different Control Groups

	Gasoline	**Gasoline**	**Gasoline**	**Diesel**	**Diesel**	**Diesel**	**Ethanol**	**Ethanol**	**Ethanol**
Treated	0.117***	0.237***	0.193***	0.124***	0.149***	0.122***	0.071***	0.202***	0.181***
	(0.019)	(0.021)	(0.022)	(0.023)	(0.021)	(0.023)	(0.023)	(0.030)	(0.032)
Obs.	183,056	672,159	583,473	235,049	885,047	771,096	164,525	613,398	497,262
R^2	0.962	0.952	0.951	0.972	0.970	0.969	0.950	0.944	0.941
Fixed Effect: City	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fixed Effect: Time	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fixed Effect: Brand	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fixed Effect: Capital	✓	✓	✓	✓	✓	✓	✓	✓	✓
Inside NE	✓			✓			✓		
Excluding NE and N		✓			✓			✓	
Excluding NE and BA border			✓			✓			✓

Source: Elaborated by author. Notes Robust standard errors are in parentheses, adjusted for clustering by city. This adjustment accurately reflects the potential correlation of data points within the same city, ensuring more reliable standard error estimations. The symbols *, **, and *** signify the rejection of the null hypothesis at significance levels of 10%, 5%, and 1%, respectively. This analysis evaluates fuel prices in their actual values, making 'Treated' a key variable that represents the marginal effect of privatization on these prices. The study employs different regional groupings to analyse the impact of privatization across various geographic configuration: ‘Inside NE’ considers all states of Northeast region as control group; ‘Excluding NE and N’ considers all regions as control group except for Northeast and North and ‘Excluding NE and BA border’ considers as control group only the states that does not belong to Northeast region and does not have a fronter with Bahia.

When excluding the Northeast and Northern regions, the analysis unveils a more pronounced increase in fuel prices compared to the baseline model. Gasoline, diesel, and ethanol prices rise by approximately 0.24 BRL, 0.15 BRL, and 0.20 BRL, respectively. These findings indicate a substantial impact of privatization beyond the initial baseline estimates, underscoring the robustness of the results and highlighting that privatization affects fuel prices with greater intensity in Bahia when compared to outside the Northeast and North regions.

Notably, the considerable increase in ethanol prices in these areas suggests distinctive market dynamics and a higher reliance on ethanol compared to the Northeast. This detailed analysis not only supports the baseline findings but also provides a comprehensive view of how privatization's impacts vary across different geographical landscapes in Brazil.

In regions excluding the Northeast and the borders of Bahia, the analysis reveals nuanced insights. Here, the impact of privatization on fuel prices remains significant, with coefficients of approximately 0.19 BRL for gasoline, 0.12 BRL for diesel, and 0.18 BRL for ethanol. While still indicating substantial price increases, these results suggest a slightly moderated impact compared when excluding Northeast and North regions.

This observation confirming the baseline results, as it demonstrates a gradient in the effect of privatization based on geographic proximity to the epicentre of policy change. The robustness analysis, in this context, serves as a crucial tool in understanding the varying degrees of impact when the fuel price in Bahia is compared to different regions, strengthening the baseline findings, and providing a more layered interpretation of privatization's implications not only in Bahia but also in the region attended by the refinery.

In the comprehensive analysis of the fuel market in Bahia, researchers delve into the intricacies of fuel demand estimation, a key factor in grasping the economic consequences of privatizing the oil industry. Table 4 illustrates the impact of fluctuations in fuel prices and income on the demand for gasoline, diesel, and ethanol. Using a log-log model, the research determines the elasticity of demand for each type of fuel, shedding light on consumer reactions to price shifts in a post-privatization environment.

Table 4 – Fuel Demand in Bahia

	Gasoline	**Diesel**	**Ethanol**
Gasoline price (log)	-1.455***		4.598***
	(0.269)		(1.459)
Ethanol price (log)	0.934***		-5.310***
	(0.278)		(1.517)
Diesel price (log)		-0.690***	
		(0.072)	
Income proxy (log)	0.408***	0.446***	0.807***
	(0.008)	(0.010)	(0.043)
Obs	3,243	3,354	3,243
R^2	0.468	0.387	0.134
Instruments			
Gasoline prices (neighbors, log)	✓		
Diesel prices (neighbors, log)		✓	
Ethanol prices (neighbors, log)	✓		✓
Distance to the closest refinery (level)	✓	✓	
Global oil price (level)	✓	✓	
Global sugar price (level)	✓		✓
Endogenous price	Gasoline and Diesel	Diesel	Ethanol

Source: Elaborated by author. Notes: Standard errors are in parentheses. The symbols ∗, ∗∗, and ∗∗∗ denote rejections of the null hypothesis at significance levels of 10%, 5%, and 1%, respectively. The model is specified in a log-log form, with the estimated parameters representing elasticities.

The price elasticity of demand for gasoline in Bahia, demonstrating a negative value, highlights the significant sensitivity of gasoline demand to price fluctuations. This data indicates that a 1% rise in gasoline prices leads to a 1.455% decrease in demand, underlining the strong price responsiveness of Bahian gasoline consumers. The interaction between gasoline and ethanol prices is also noteworthy; an increase in ethanol prices, with a cross-elasticity of 0.934, drives up gasoline demand, showcasing their interchangeable nature in the fuel market.

When examining the ethanol market, it exhibits greater elasticity compared to gasoline; a 1% increase in price results in a substantial 5.31% decrease in demand. Similar to gasoline, ethanol displays positive and statistically significant cross-price elasticity. A 1% increase in gasoline prices leads to an approximate 4.6% rise in ethanol demand, confirming the fluid interchangeability between these two fuel types. In contrast, diesel demonstrates more inelastic behaviour; a 1% price increase only

results in a 0.69% drop in demand, indicating a less price-sensitive market compared to gasoline and ethanol.

The price elasticity of demand for gasoline in Bahia, as previously discussed, shows a negative value, indicating significant sensitivity to price changes. This is consistent with the findings of Uchôa, Silva de Jesus and Cardoso (2020), in their analysed fuel demand elasticities across Brazil. Their research concluded that demands for gasoline, ethanol, and diesel are all price elastic. Furthermore, they highlighted the significant impact of the ethanol-to-gasoline price ratio on the demands for both fuels.

The next step of this research is the welfare analysis, focusing on the economic impacts following the privatization of the RLAM refinery. This analysis is vital in assessing the broader socio-economic consequences of privatization, particularly in terms of consumer surplus and overall economic welfare. Table 5 is designed to measure the change in consumer surplus, reflecting the economic burden on consumers due to changes in fuel prices, providing a comprehensive picture of how privatization has reshaped the economic perspective for fuel consumers in Bahia.

Table 5 – Welfare Analysis after 22 months of RLAM privatization

	Gasoline	**Diesel**	**Ethanol**	**Total**
Fuel Sold After RLAM privatization (billion, litters)	4.071	6.089	0.830	
Overprice (BRL)	0.218	0.141	0.193	
Area A (billion, BRL)	0.887	0.858	0.160	1.905
Own-price elasticity	-1.455	-0.690	-5.310	
Cross-price elasticity	0.934		4.598	
Overprice/Price	3.38%	2.12%	3.45%	
∆Consumption	-4.92%	-1.46%	-18.30%	
Area B (billion, BRL)	0.022	0.006	0.015	0.043
A+B (billion, BRL)	**0.909**	**0.864**	**0.175**	**1.948**

Source: Elaborated by author based on ANP data. Notes: The term "Overprice" refers to the change in price (∆P), which is derived from the coefficients listed in Table 2. To calculate Area A, multiply the overprice by the quantity of fuel sold following the RLAM privatization. The own-price elasticity and cross-price elasticity values are obtained from demand estimation analysis. The ratio of Overprice to Price is determined by considering the average pre-privatization prices for gasoline (6.45 BRL), diesel (6.67 BRL), and ethanol (5.60 BRL). The change in consumption (∆Consumption) is computed using the formula: Elasticity × (Overprice/Price). With the original quantity of fuel sold, is possible to

determine the change in quantity (∆Q) by applying the formula: Original Quantity × (∆Consumption). Once ∆Q is ascertained, Area B can be measured using the formula: (∆P×∆Q)/2, where ∆P represents the overprice and ∆Q represents the change in quantity. This calculation yields the Area B, which visually represents a triangle on a graph, capturing the economic impact of price changes on quantity.

After RLAM privatization, fuel sales consisted of 4.071 billion litters of gasoline, 6.089 billion litters of diesel, and 0.830 billion litters of ethanol. The estimation of ∆P is BRL 0.218 for gasoline, BRL 0.141 for diesel, and BRL 0.193 for ethanol, indicating significant price rises. These increases adversely affected consumer welfare, as shown by Area A in the table, which illustrates the decline in consumer surplus due to overpricing. The overall loss totalled BRL 1.905 billion, with individual losses for gasoline, diesel, and ethanol being BRL 0.887 billion, BRL 0.858 billion, and BRL 0.160 billion, respectively.

The study also examines the own-price elasticity of demand for each type of fuel, shedding light on how consumers react to price changes. The elasticity was -1.455 for gasoline, -0.690 for diesel, and a much higher -5.310 for ethanol, indicating that ethanol consumers are more affected by price changes. The change in consumption, labelled as ∆Consumption, revealed a decrease of -4.92% for gasoline, -1.46% for diesel, and a substantial -18.30% for ethanol due to overpricing, showing a significant drop in fuel usage.

Moreover, the analysis estimates Area B, which accounts for the additional consumer surplus loss caused by decreased fuel consumption. The cumulative losses of Areas A and B, representing both direct and indirect effects of price hikes, amounted to a total economic impact of BRL 1.948 billion on Bahia's fuel consumers. The overall effects for gasoline, diesel, and ethanol were BRL 0.909 billion, BRL 0.864 billion, and BRL 0.175 billion, respectively.

5. FINAL REMARKS

This analysis of the privatization of the RLAM, provides a significant understanding of the short-term impacts on fuel prices and consumer welfare. The study's findings are critical in highlighting the immediate effects of shifting from state to private control. However, it's essential to recognize that the observations made are based on a relatively short timeframe post-privatization. This temporal limitation

suggests that the current outcomes may not fully capture the long-term consequences of such a major policy shift.

The immediate increase in fuel prices and the consequent reduction in consumer surplus, underscore the complexity and potential challenges of privatization. While the study indicates a negative short-term impact on consumer welfare, the long-term effects of privatization on efficiency, market competitiveness, and overall economic health remain to be seen. It is possible that as the market adjusts and stabilizes over time, some of the initial negative impacts might be mitigated, potentially leading to benefits that are not immediately observable.

Furthermore, this study's methodology and findings are particularly relevant for policymakers and stakeholders contemplating similar privatization initiatives in other sectors or regions. The insights gleaned from this analysis offer a solid background for understanding the immediate effects of privatization and can inform decisions regarding other refineries or state-controlled entities that might undergo similar processes. This is especially pertinent in the context of a global energy landscape that is increasingly leaning towards privatization and market-driven operations.

Moreover, subsequent studies could investigate the long-term effects on market structure and competition. Understanding how the market evolves in terms of competition, pricing strategies, and consumer choices is essential for assessing the overall success of privatization. This would also involve exploring whether new market entrants emerge and how they affect market dynamics, potentially leading to a more competitive and efficient market. In addition, future research could also explore other dimensions of privatization. This includes examining the broader socio-economic impacts, such as employment changes, regional economic development, and environmental considerations.

In conclusion, while this research provides crucial perceptions into the short-term impacts of the RLAM’s privatization, it also opens avenues for further investigation into the long-term effects and broader implications of such policy decisions. The study serves as a reminder of the multifaceted nature of privatization and its varying impacts across different time horizons and socio-economic dimensions.

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